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INSTRUCTION MANUAL

INSTRUCTION MANUAL
FOR
ROD ANTENNA PREAMP
MODEL 94607–1

(For Use With Model NM–17/27 FI Meter)

Manual No. 1–500783–284
(For Use With Serial Numbers 101 and Above)

SINGER
INSTRUMENTATION

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The Singer Company, Los Angeles Operation • 5340 Alla Road, Los Angeles, Ca. 90066

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2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Has maintenance action been previously requested.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

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Figure 1-1. Model 94607-1 Rod Antenna Preamp with Supplied Accessories (foreground) and with Rod Antenna Model 92197-3

Section 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Singer Rod Antenna Preamp, Model 94607-1, was designed for use with the Singer Model NM-17/27 EMI/FI Meter, but may be used with other, similar instruments, having 50 ohm input impedance. The Rod Antenna Preamp and associated 41-inch telescopic Rod Antenna (See Figure 1-0), and ground plane are calibrated for performing electric field strength measurements within the frequency range of 10 kHz to 32 MHz. The Antenna Preamp may be mounted on a standard (91933-2) tripod. Power is obtained from the Model NM-17/27 Meter, via the 1-004915-001 power cable.

1.2 OPERATIONAL FEATURES

The Model 94607-1 Rod Antenna Preamp provides a wide operational bandwidth, covering the frequency range of 10 kHz to 32 MHz without bandswitching or tuning. The Antenna Preamp matches the high impedance of the 41-inch Rod Antenna to a 50 ohm unbalanced load. A substantially constant (±1 dB) antenna correction factor of +20 dB is maintained over the 10 kHz to 32 MHz frequency range.

The Model 94607-1 Antenna Preamp may be used with the Model NM-17/27 for making high impedance conducted measurements (using the supplied 1-910209-001 or 1-910210-001 Banana Plug adapters instead of the 41" rod antenna). A substantially constant matching factor of +14 dB (±1 dB) is maintained over the 10 kHz to 32 MHz frequency range.

1.3 ACCESSORIES

1.3.1 Supplied Accessories

The items listed in Table 1-1 are furnished with the Model 94607-1 Rod Antenna Preamp.

Table 1-1. Supplied Accessories

Quantity	Device	Singer Model/Part Number
1	Power Cable, 20 feet	1-004915-001
1	Banana Plug to Binding Post Adapter	1-910209-001
1	Banana Plug to BNC Adapter	1-910210-001
1	Instruction Manual	1-500783-284

1.3.2 Required Accessories

For complete operation of the Model 94607-1 Rod Antenna Preamp, it is necessary to have the following accessories, in addition to the supplied accessories listed in Paragraph 1.3.1.

a. Rod Antenna, 41 inches, Model 92197-3. Used with Rod Antenna Preamp for measuring electric field strength.

b. Ground Plane, Model 92199-3. Used with Rod Antenna Preamp and Rod Antenna as directed by measurement specifications to provide a true signal ground.

c. RF Transmission Line, Model 92191-1, 20 ft., BNC to BNC. Used for connecting the Model 94607-1 Rod Antenna Preamp to the Model NM-17/27 within a distance of 20 ft.

1.3.3 Optional Accessories

a. Collapsible Tripod, Model 91933-2. Used for mounting the Model 94607-1 Rod Antenna Coupler and the Model 92199-3 Ground Plane.

Section II

SPECIFICATIONS

2.1 INTRODUCTION

This section contains specification information for the Rod Antenna Preamp, Model 94607-1.

2.2 SPECIFICATIONS

Three sets of specifications are presented: General specifications pertaining to the Model 94607-1 Rod Antenna Preamp, Table 2-1; specifications involving the Model 94607-1 Rod Antenna Preamp combined with the Model 92197-3 Rod Antenna for radiated measurements, Table 2-2; and specifications involving the Model 94607-1 Rod Antenna Preamp used with the P/N 1-910209-001 Banana Plug to Binding Post Adapter for high impedance conducted measurements, Table 2-3.

Table 2-1. Specifications, Model 94607-1
Rod Antenna Preamp

Characteristics	Specified Parameters	Supplementary Information
Frequency Range:	10 kHz to 32 MHz	Approximately 3 kHz to 50 MHZ for 3 dB down bandpass, see Figure 5-1.
Frequency Bands:		One
Input Impedance:		100 megohms shunted by 10 pF
Load Impedance:		50 ohms, VSWR less than 1.2
Voltage Gain:	-14 dB ± 1 dB	Input to Output, 10 kHz to 32 MHz
Max. Input Voltage:	2.5 volts	For 1 dB compression of output signal level.
Power Requirement:		±12.00 volts at 20 ma.
Weight:		0.71 kg (1 pound, 9 ounces)
Dimensions:		13.6 cm (5 3/8") high 13.3 cm (5 1/4") wide 10.8 cm (4 1/4") deep
Temperature Range:		Operational: -15°C to +50°C Non-operational: -50°C to +75°C

Table 2-2. Specifications, Model 94607-1 Rod Antenna Preamp with Model 92197-3 41" Rod Antenna

Characteristic	Specified Parameters	Supplemental Information
Antenna Effective Height:		0.5 meters
Antenna Correction Factor (ACF):	+20 dB ± 1 dB	Includes preamp loss, 10 kHz to 32 MHz
Sensitivity:		
Narrowband:	See Figure 2-1	With NM-17/27; 100 Hz and 1 kHz BW
Broadband:	See Figure 2-2	With NM-17/27; 1, 10 and 50 kHz BW
Maximum Signal Voltage (overload):		For 1 dB compression of output signal level.
Narrowband:	+14 dBV/meter	5V/meter
Broadband:	+86 dBμV/m/MHz	.02V/meter/MHz

Table 2-3. Specifications, Model 94607-1 Rod Antenna Preamp with P/N 1-910209-001 or 1-910210-001 Adapter

Characteristic	Specified Parameters	Supplemental Information
Input Impedance:		Equivalent to 6 pf
High Impedance Factor:	+14 dB ± 1 dB	Includes Preamp loss, 10 kHz to 32 MHz
Sensitivity:		
Narrowband:	See Figure 2-3	NM-17/27, 100 Hz and 1 kHz BW
Broadband:	See Figure 2-4	NM-17/27, 1, 10 and 50 kHz BW
Maximum Signal Voltage (overload):		For 1 dB compression of output signal level.
Narrowband	+8 dBV	2.5 Volts
Broadband	+80 dBΩV/MHz	0.01V/MHz

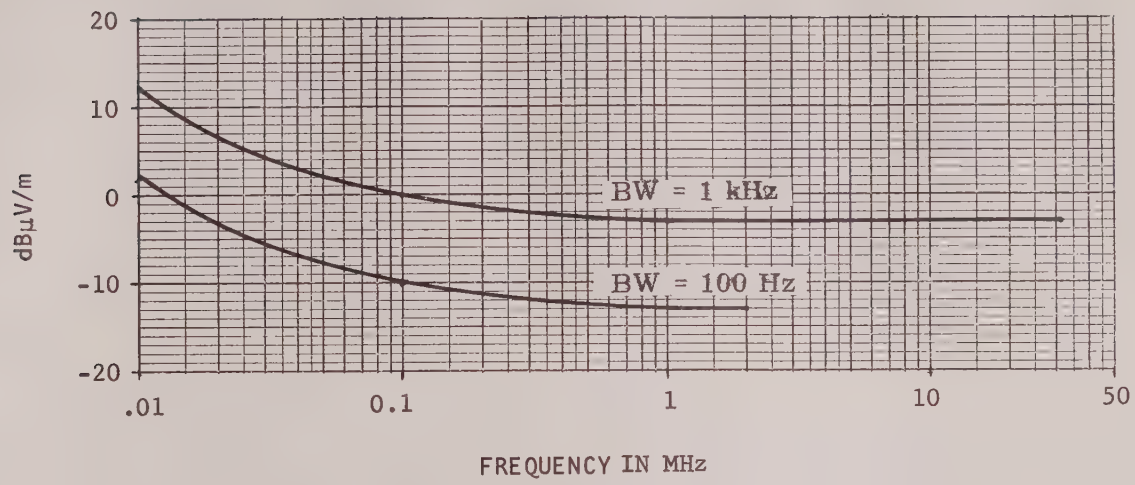


Figure 2-1. Narrowband (CW) Radiation Sensitivity (Model 94607-1 Antenna Preamp with Model 92197-3 41" Rod Antenna and Model NM-17/27 EMI/FI Meter)

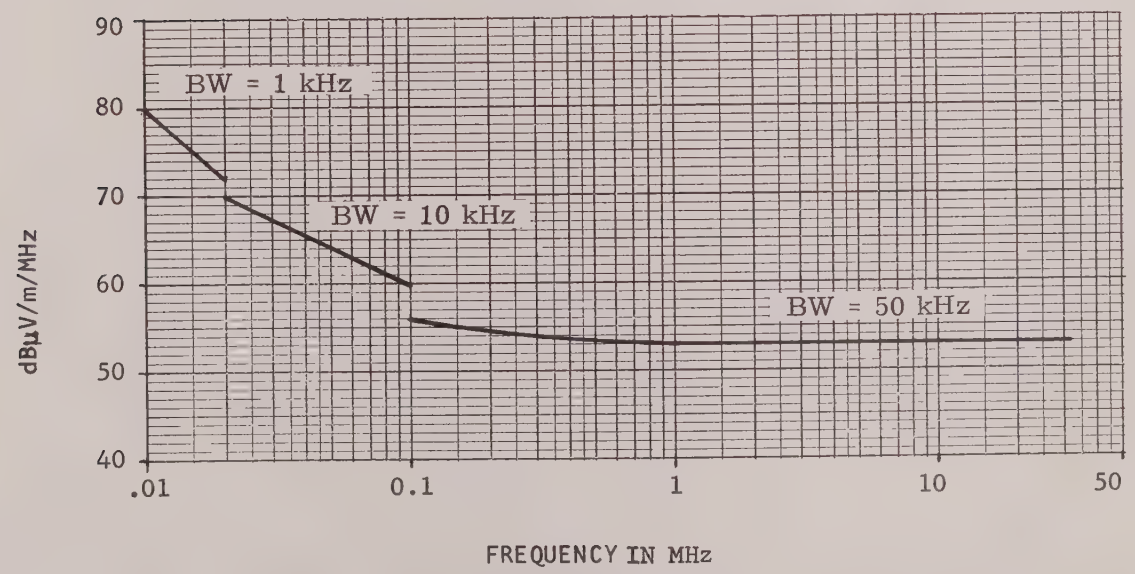


Figure 2-2. Broadband (BB) Radiation Sensitivity (Model 94607-1 Antenna Preamp with Model 92197-3 41" Rod Antenna and Model NM-17/27 EMI/FI Meter)

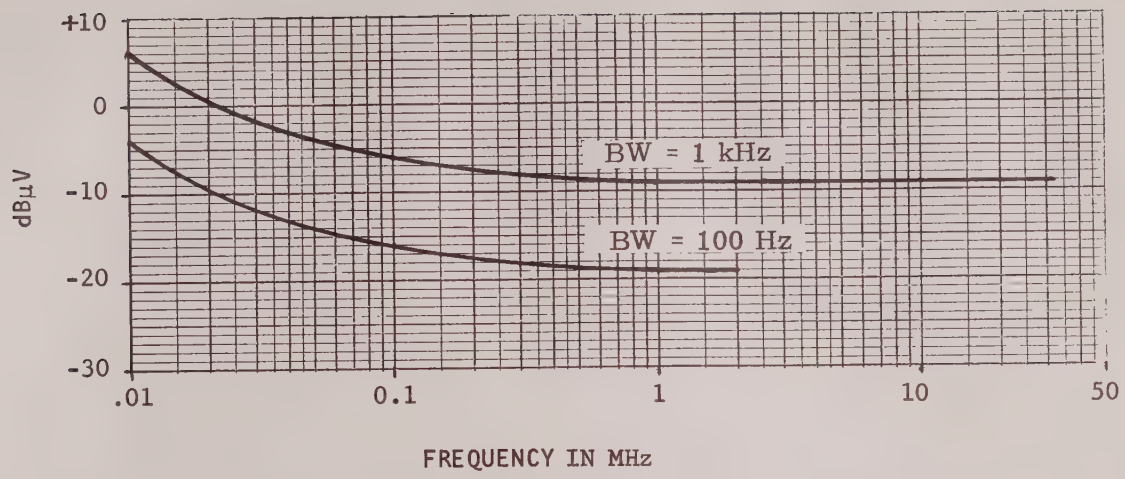


Figure 2-3. Narrowband (CW) Sensitivity, High Impedance Conductive (Model 94607-1 Antenna Preamp with P/N 1-910209-001 Adapter and Model NM-17/27 EMI/FI Meter)

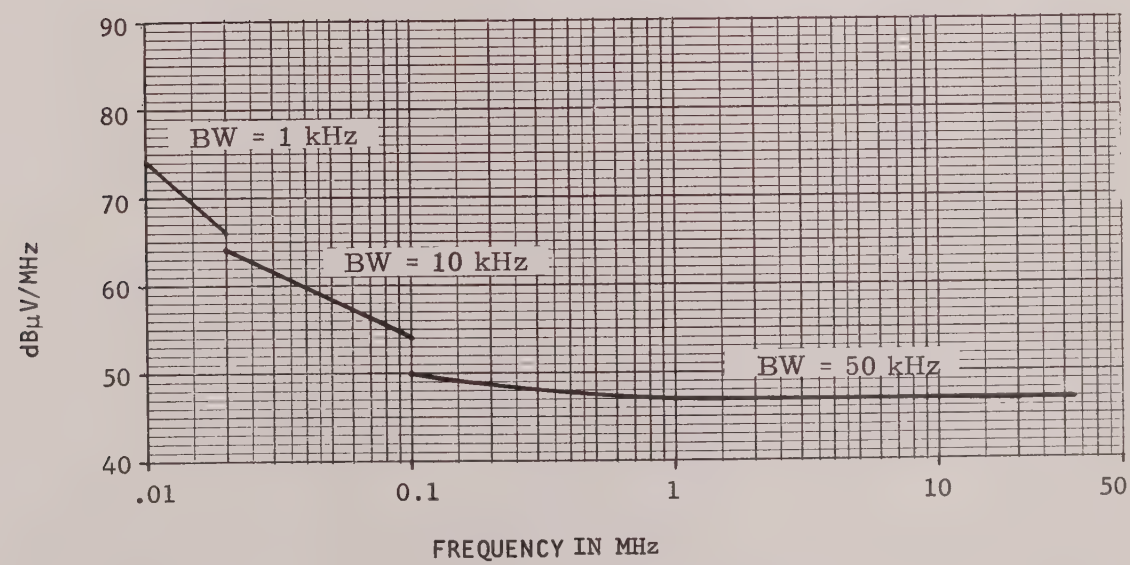


Figure 2-4. Broadband Sensitivity, High Impedance Conductive (Model 94607-1 Antenna Preamp with P/N 1-910209-001 Adapter and Model NM-17/27 EMI/FI Meter)

Section III

OPERATING CONTROLS, INDICATORS, AND RECEPTACLES

3.1 INTRODUCTION

Functional descriptions of all Model 94607-1 Rod Antenna Preamp receptacles are provided in this section of the manual.

3.2 RECEPTACLES

All external receptacles are located in Figure 3-1. Functions are described in Table 3-1. Pin data for the power receptacle, J3, is given in Table 3-2.

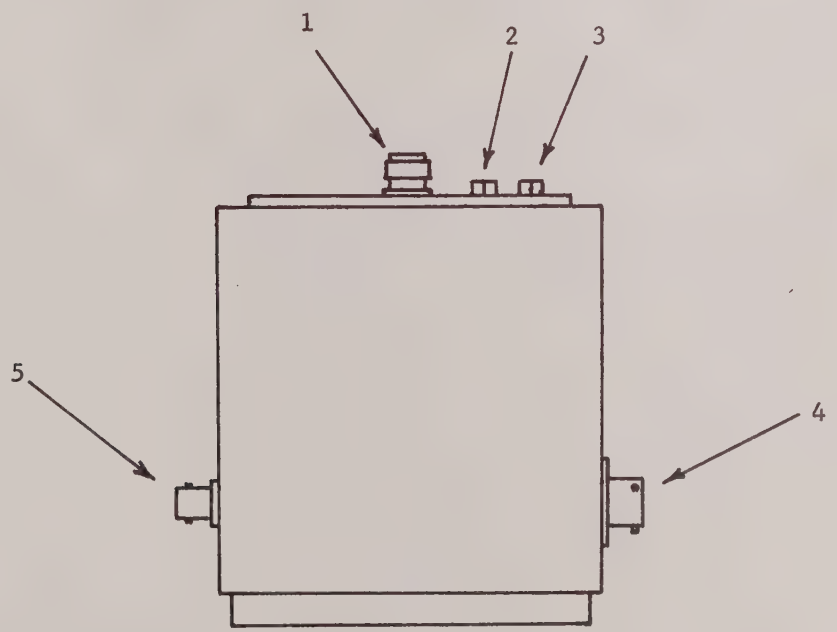


Figure 3-1, Receptacles, Model 94607-1

Table 3-1. Receptacles (Keyed to Figure 3-1)

Item	Panel Marking	Description	Function
1		TNC Receptacle (J1)	Provides RF input from rod antenna
2		Banana Jack (J5)	Provides RF input for high impedance conducted measurements.
3		Banana Jack (J4)	Provides ground connection for high impedance conducted measurements.
4		Receptacle, 6 pin (J3)	Provides power input from the Model NM-17/27.
5	RF OUTPUT	BNC Receptacle (J2)	Provides RF output.

Table 3-2. Power Receptacle Pin Data (J3)

Pin	Function
A	Not Used.
B	-12V from the Model NM-17/27 or other power source.
C	Not Used.
D	Provides dc ground between Model 94607-1 and the Model NM-17/27 or other power source.
E	Not Used.
F	+12V from the Model MN-17/27 or other power source.

Section IV

INSTALLATION

4.1 PREPARATION FOR USE

4.1.1 Radiation Measurements

a. Attach the Rod Antenna Preamp to the Ground Plane using the two 8-32 mounting screws in the base of the Antenna Preamp Housing Base.

NOTE

For RF field strength measurements, the Ground Plane is not large enough to constitute a true signal ground. The Ground Plane may be enlarged by attaching a network of radial wires, conductive mesh, etc. to the Ground Plane. Up to 24 radial wires may be attached to the Ground Plane and the length of each wire must equal, or exceed the height of the Antenna. The Rod Antenna correction factors are accurate only when a true signal ground is used.

b. The Ground Plane may be placed on the ground or may be mounted on the Model 91933-2 Tripod or equivalent tripod.

c. Connect the telescopic Rod Antenna, Model 92197-3, to the insulated, modified TNC receptacle on the top of the Antenna Coupler housing then extend to its maximum length (41") during use.

d. Connect the Rod Antenna Preamp RF OUTPUT receptacle to the Model NM-17/27 EMI/FI Meter RF input receptacle with a 50 ohm RF transmission line (Singer P/N 92191-2 or equivalent).

e. Attach the Power Cable, P/N 1-004915-001, between the Model 94607-1 power input receptacle and the AUX PWR receptacle on the rear panel of the Model NM-17/27 or other + and - 12V source.*

4.1.2 High Impedance Conducted Measurements

a. When performing high impedance conducted measurements, the Model 92197-3 41" Rod Antenna is not used. Instead, the Banana Plug to Binding Post Adapter (P/N 1-910209-001) or the Banana Plug to BNC Adapter (P/N 1-910210-001) is attached to the banana jack receptacles on the top of the Antenna Preamp housing.

b. Connect the Preamp RF OUTPUT receptacle to the Model NM-17/27 EMI/FI Meter RF input receptacle with a 50 ohm RF transmission line (Singer P/N 92191-2 or equivalent).

c. Attach the Power Cable (P/N 1-004915-001) between the Model 94607-1 power input receptacle and the AUX PWR receptacle on the back panel of the Model NM-17/27 or other suitable + and - 12V source.*

d. Connect the signal source to be measured to the adapter output. Use short connections when the Banana Plug to Binding Post Adapter is used.

* Early Model NM-17/27 did not have the AUX PWR receptacle. A modification kit, P/N 1-60119-002, is available to add this receptacle. Alternatively, the Power Cable may be modified to connect the Model 94607-1 to the Model NM-17/27 PROGRAMMER receptacle to obtain power. Remove the connector from one end of the Power Cable and re-connect the cable to the 41 pin connector, P/N 1-910101-005, supplied with Model NM-17/27 as in Table 4-1.

Table 4-1. Modified Power Cable Wiring

Voltage	6 Pin Connector Pin No.	41 Pin Connector Pin No.
+12V	F	t
-12V	B	s
GND	D	U

Section V

OPERATION

5.1 INTRODUCTION

Instructions for making radiation measurements and high impedance conducted measurements when the Model 94607-1 Preamp is connected to the Model NM-17/27 EMI/FI Meter are presented in this section of the manual.

5.2 OPERATING PROCEDURES

5.2.1 Radiation Measurements in terms of dBμV/m

a. Interconnect the equipment as described in Paragraph 4.1.1.

b. Tune the Model NM-17/27 EMI/FI Meter for maximum response to the desired signal.

c. Make a measurement of the RF voltage across the RF input to the Model NM-17/27 in terms of dB referred to one microvolt (dBμV).

d. Algebraically add the antenna correction factor (+20dB) to the measurement in step c. to obtain the radiation measurement in terms of dBμV/m.

Example: Assume a Model NM-17/27 Meter RF input voltage measurement of -10 dBμV, then the RF field strength is:

$$-10\ dB\mu V + (+20dB) = +10\ dB\mu V/m$$

5.2.2 Radiation Measurements in terms of dBμV Antenna Induced

a. Antenna induced (or antenna open-circuit) voltage measurements may be performed by repeating Paragraph 5.2.1 except subtract 6 dB from step d.

Example: -10 dBμV + (14 dB) = +4 dBμV antenna induced

5.2.3 High Impedance Measurements in terms of dBμV

a. Interconnect the equipment as described in Paragraph 4.1.2.

b. Tune the Model NM-17/27 EMI/FI Meter for maximum response to the desired signal.

c. Make a measurement of the RF voltage across the RF input to the Model NM-17/27 in terms of dB referred to one microvolt (dBμV).

d. Algebraically add the High Impedance Factor (+14 dB) to the voltage measurement in step c. to obtain the signal level across the high impedance input to the Model 94607-1 in terms of dBμV.

5.2.4 Conversion of dB Terms

Terms of dBμV or dBμV/m may be converted to microvolt or microvolt/meter terms using the following relationship:

$$\text{Microvolts} = \log_{10}^{-1}\left(\frac{\text{dB}\mu\text{V}}{20}\right)$$

Alternatively, Table 4-3, page 4-12 in the Model NM-17/27 Instruction Manual may be used.

5.2.5 Frequency Range

The Model 94607-1 Rod Antenna Preamp is designed specifically to operate with the Model NM-17/27 EMI/FI Meter over the frequency range 10 kHz to 32 MHz. The gain of the Model 94607-1 over this range is sufficiently flat (within ± 1 dB) that an Antenna Correction Factor (ACF) chart is not required when making measurements. For use outside the normal frequency range, refer to Figure 5-1 for a typical ACF chart.

5.2.6 Overload Considerations, Radiation Measurements

The Model 94607-1 Rod Antenna Preamp has many attractive features; wide frequency range - no bandswitching, essentially constant gain across the designed frequency range, and good sensitivity. These advantages are achieved by directly connecting the base of a 41" rod antenna to a high input impedance, untuned, broadband amplifier. However, the disadvantage of this antenna preamplifier is overloading on strong signals. Overload exists when the amplifier linearity departs by greater than 1 dB.

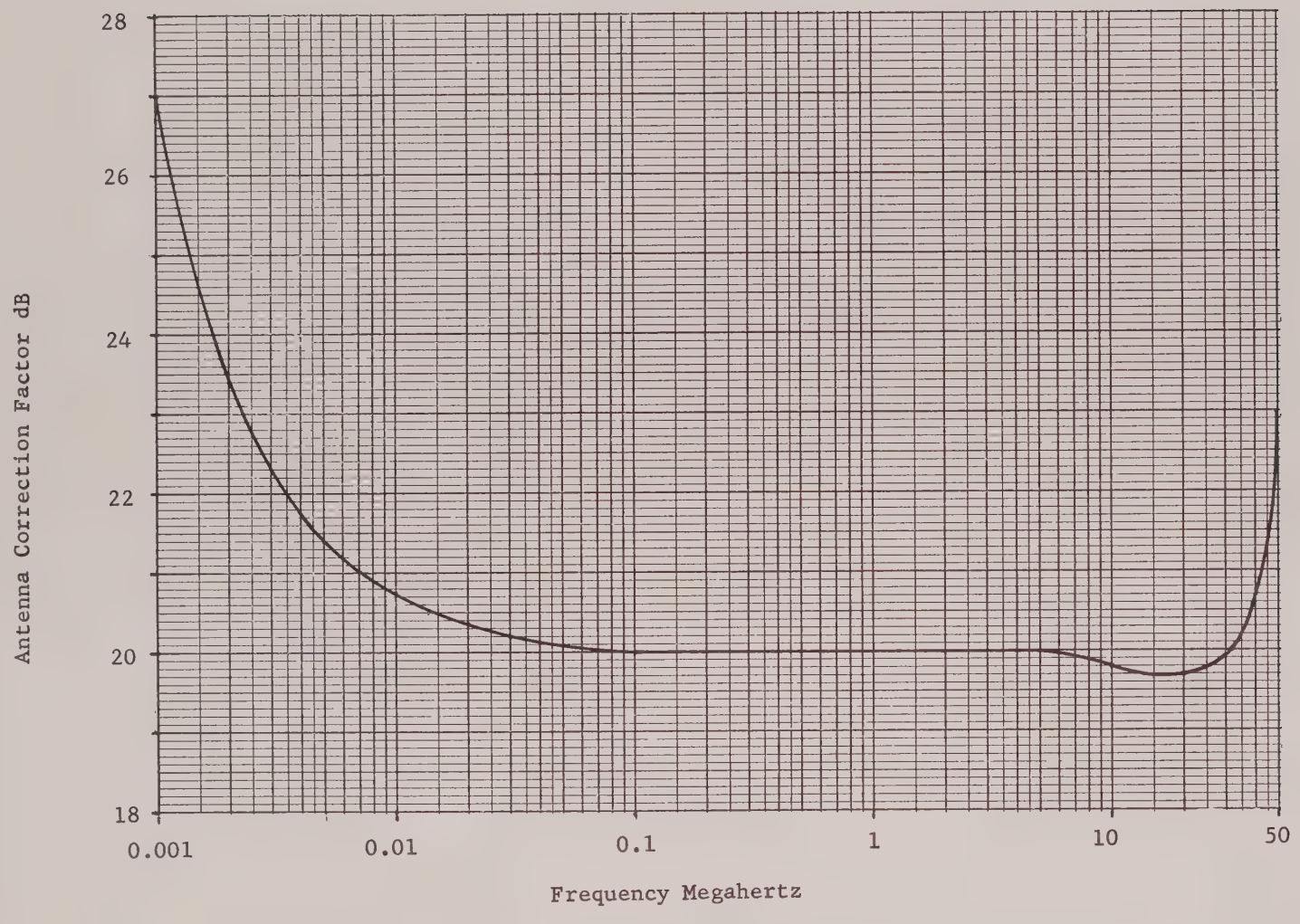


Figure 5-1. Antenna Correction Factor
Versus Frequency

When the Model 94607-1 Rod Antenna Preamp, combined with the Model 92197-3 Rod Antenna, is used within a controlled environment, such as a screenroom, radiated signals strong enough to cause overload are either not present (usually predictable), or can be reduced to a harmless level by shielding, filtering or disabling. In an outdoor environment, control of strong ambient signals is generally impractical. In either case, knowledge of signal levels required to cause overload can help in taking more reliable measurements with an active, broadband antenna. Overloading can occur with either narrowband, or broadband type signals.

5.2.6.1 Strong Narrowband Signals

The Model 94607-1 Rod Antenna Preamp with the Model 92197-3 Rod Antenna can accept a single narrowband radiated signal with an RF level up to 5V per meter without overload. A number of weaker signals are capable of combining in a complex manner for a resultant voltage level exceeding 5V per meter. It is suggested that the operator perform the following procedure at a given test site prior to taking final measurements of radiated signals.

a. Interconnect the equipment as described in Paragraph 4.1.1.

b. Calibrate the Model NM-17/27 equipment at 1.5 MHz.

c. Set the Model NM-17/27 Function switch to Peak, hold time to 0.3 secs, and set the Attenuator control to the +60 dB position.

d. Slowly tune the Model NM-17/27 across the frequency range 10 kHz to 32 MHz, noting the level of any signal exceeding 40 dB on the output meter scale. A 1 V/m signal level would register 40 dB, a 5 V/m signal level would register 54 dB.

e. If an NM-37/57 equipment is available, continue the test up through the FM band (108 MHz).

IF one or more signals exceeds 54 dB on the output meter scale, overload is taking place and measurements taken at any frequency will be in error. IF all signals are

below 40 dB on the output meter scale (less than 1 volt/m), overload is not likely from narrowband signals. If several signals exceed 1 volt, but are less than 5 volts, they can add as the square root of the sum of the squares, worse case. For example: Assume signals of 1.2, 3.3, 2.2, and 2.7 volts; adding together, worse case:

$$E_s = \sqrt{(1.2)^2 + (3.3)^2 + (2.2)^2 + (2.7)^2} = 4.94 \text{ volts}$$

NOTE

25 one volt signals, adding worse case, are required to provide a 5 volt level.

5.2.6.2 Strong Broadband Signals

Overloading as a result of broadband signals is not as apparent as that caused by narrowband signals. Moreover, impulse type signals can add directly to narrowband signals causing a signal overload condition that may be difficult to visualize. The following procedure is suggested for determining overload conditions from broadband signals:

a. Interconnect the equipment as described in Paragraph 4.1.1.

b. Calibrate the Model NM-17/27 equipment at 1.5 MHz.

c. Set the Model NM-17/27 Function switch to Peak, hold time 0.05 seconds; set the bandwidth to 50 kHz, and the Attenuator to 0 dB position.

d. Tune the Model NM-17/27 across the 0.25 to 32 MHz frequency range. Ignore all tuneable, narrowband signals, noting, instead, the level of broadband background interference.

If the broadband background level is impulsive in character (level varies directly with bandwidth), and if it is broadband in nature (has about the same intensity across the frequency range), overload will occur when the level exceeds 40 dB on the Model NM-17/27 output meter. The limiting level (for impulse signals alone) is +86 dBμV/m/MHz.

5.2.7 Overload Considerations, High Impedance Conducted Measurements

5.2.7.1 Strong Narrowband Signals

Use the same procedure presented in Paragraph 5.2.6.1 except use equipment interconnection from Paragraph 4.1.2 and all levels would decrease by 6 dB or by a factor of two.

5.2.7.2 Strong Broadband Signals

Use the same procedure presented in Paragraph 5.2.6.2 except use equipment interconnection from Paragraph 4.1.2 and all levels would decrease by 6 dB or by a factor of two.

Section VI

THEORY OF OPERATION

6.1 INTRODUCTION

This section contains the theory of operation of the Model 94607-1 Rod Antenna Preamp. This analysis is presented as an aid in understanding the operation of the unit as well as an insight in troubleshooting should a fault occur.

6.2 CIRCUIT ANALYSIS

6.2.1 Rod Antenna Model 92197-3

The telescopic rod antenna is extended to a maximum length of 41 inches when in use. At this length, the rod antenna has a capacity to an ideal ground plane of 10 picofarads. The rod antenna represents a high impedance source (typically 100 kilohms at 150 kHz and 500 ohms at 32 MHz) as compared to the 50 ohm RF input impedance of the EMI/FI Meter. Therefore, the Model 94607-1 is used to match this high impedance source to the 50 ohm input to the EMI/FI Meter. Refer to Appendix A for additional information on the rod as a receiving antenna.

6.2.2 Rod Antenna Preamp, Model 94607-1, refer to schematic, Figure 9-1

The Preamp input impedance is 100 megohms shunted by approximately 10 picofarads. The voltage gain of the amplifier is essentially constant from 10 kHz to 32 MHz and is adjusted to -14 dB when operating with a 10 picofarad signal source and a 50 ohm termination at the RF OUTPUT. The -14 dB gain was chosen rather than 0 dB (or higher gain) to provide increased amplifier dynamic range or overload capability when the antenna is in the presence of strong signals.

The input signal, from the rod antenna receptacle J1, is applied to capacitive voltage divider C2 and C3. Capacitor C3 is adjustable and controls the overall gain of

amplifier. It is important to note that the signal level is controlled ahead of the first amplifier stage to preserve dynamic range.

The amplifier consists of a two-stage wideband amplifier employing a silicon, field-effect transistor source follower as the first stage, and a complementary - symmetry emitter follower as the second stage. The FET, Q1, is a N-channel, depletion mode junction FET with very low internal noise. L1 is a high-frequency peaking coil used to increase the amplifier bandwidth. Trimming capacitor, C4, modifies the high frequency response of the amplifier and is adjusted for minimum gain variation over the frequency range. Q2 and Q3 form the complementary-symmetry emitter flower output stage that can operate class B to increase output swing and increased dynamic range. This circuit is designed to operate at a very low output impedance; the value of series resistor, R9, in the output circuit was selected to provide a source impedance of 50 ohms. Ferrite beads E1, E2 and E3 are used as RF chokes to suppress high frequency parasitics that might be generated by the transistors. The design technique used in the output stage depends on driving the load from different devices, Q2 and Q3, on the two halves of the input cycle. Output current is supplied by Q2 on the positive half cycle and by Q3 on the negative half cycle. R5 adjusts the current balance between Q2 and Q3 for maximum dynamic range.

When high impedance conducted measurements are to be made, the rod antenna is removed from receptacle, J1, and the conducted signal is applied between jacks J4 and J5. A dummy antenna, C1, of 10 pF is placed in series with the signal so the capacitance across the input capacitive attenuator C2, C3 remains the same (as with the rod antenna) preserving the gain and calibration of the Preamp.

Section VII

MAINTENANCE

7.1 INTRODUCTION

This section of the manual contains minimum performance procedures, disassembly procedure, alignment and adjustment procedures, and fault isolation procedures for the Model 94607-1 Rod Antenna Preamp. The minimum performance procedures are intended to verify that the Model 94607-1 is functioning in accordance with the specification requirements listed in Section II.

The alignment, adjustment, and fault isolation procedures are only intended for use when the Model 94607-1 does not meet the specification requirements. No scheduled, periodic maintenance is required.

7.2 TEST EQUIPMENT REQUIRED

The test equipment required for the Minimum Performance Procedures, Alignment and Adjustment Procedures is listed in Table 7-1. Minimum specification parameters, required of the test equipment to perform the required performance and alignment procedures, are provided as an aid in the selection of equivalent instruments.

7.3 MINIMUM PERFORMANCE PROCEDURES

The procedures contained in this Paragraph may be used to establish the performance of the Model 94607-1 Rod Antenna Preamp within acceptable limits. Each procedure is complete, independent of others.

7.3.1 Evaluation of Frequency Range and Voltage Gain

a. Interconnect the equipment as shown in Figure 7-1.

b. Energize the equipment.

Table 7-1. Test Equipment Requirements

Instrument	Minimum Parameters	Recommended Mfg.	Recommended Model	Use *
Signal Generator	Frequency Range: 50 kHz to 32 MHz Calibrated Output: 1μV to 2.5 V Impedance: 50 ohms	Hewlett-Packard	606A	A,M
Signal Generator	Frequency Range: 10 kHz to 50 MHz Calibrated Output: 1μV to 2.5 V Impedance: 50 ohms	Hewlet-Packard	651B	A,M
RF Voltmeter	Frequency Range: 500 kHz to 32 MHz Range: 0 to -20 dBm Impedance: Terminated with 50 ohms	Hewlett-Packard	411A	A,M
AC Voltmeter	Frequency Range: 10 kHz to 500 kHz Range: 0 to 20 dBm Impedance: Terminated with 50 ohms	Hewlett-Packard	400D	A,M
DC Voltmeter	Voltage Range: 0.2 to 15 V Impedance: 10 kilohms per volt	Triplett	630A	A
EMI/FI Meter	Frequency Range: 10 kHz to 32 MHz Voltage Range: Narrowband: 0.1 μV to 1 volt Broadband: 100 to 30 KμV/MHz	Singer	NM-17/27	A,M
Impulse Generator	Frequency Range: 50 kHz to 1 GHz Spectral Output: 0 to 90 dBμV/MHz	Singer	91263-1	M
Termination	Impedance: 50 ohms VSWR: less than 1.2 Connector: BNC or type N	Narda	370	A,M

*A = Alignment and Adjustment
M = Minimum Performance Testing

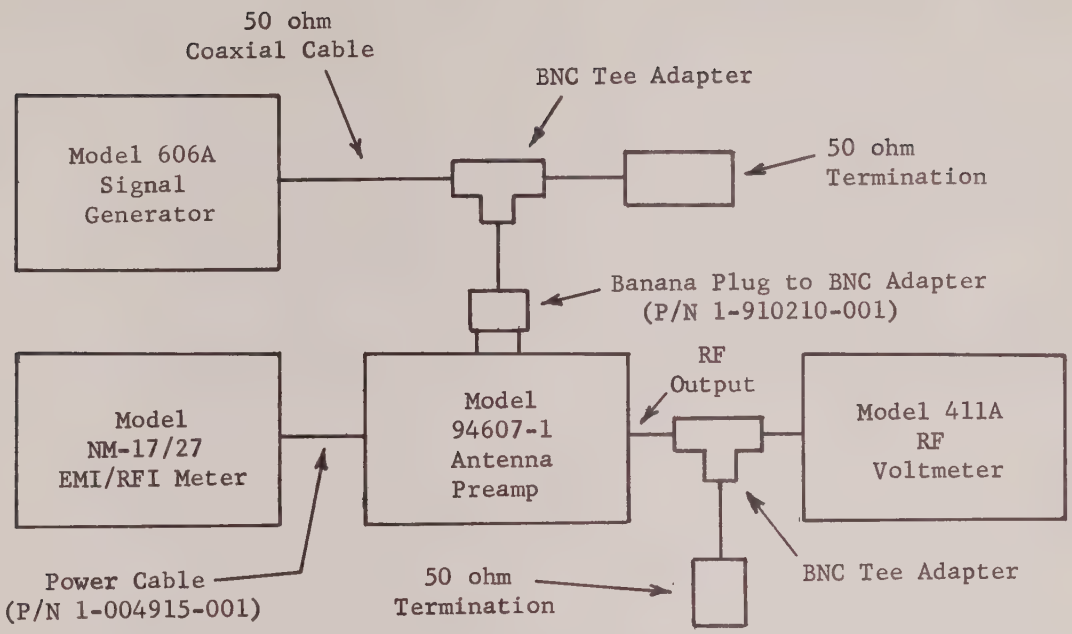


Figure 7-1. Test Setup 1

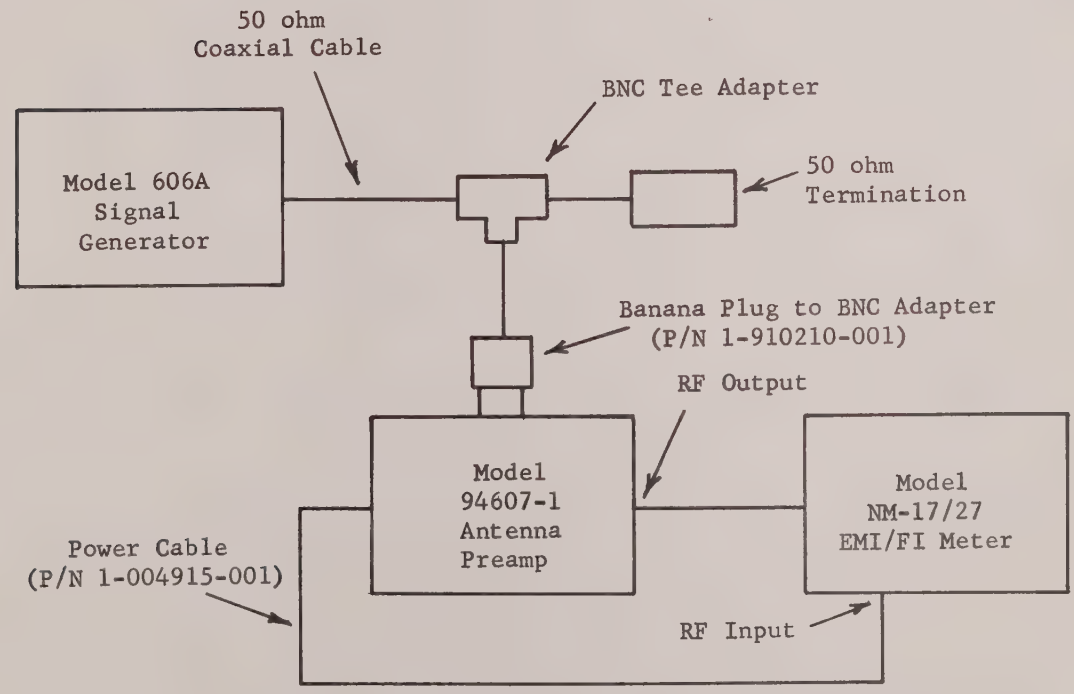


Figure 7-2. Test Setup 2

c. Adjust the Signal Generator for 0 dBm output level at 500 kHz. The RF Voltmeter should indicate -14 dBm ± 1 dBm.

d. Adjust the Signal Generator for 0 dBm output level at 32 MHz. The RF Voltmeter should indicate -14 dBm ± 1 dBm.

e. Replace the Model 606A Signal Generator with the Model 651B Signal Generator. Replace the Model 411A RF Voltmeter with the Model 400D AC Voltmeter. Adjust the Model 651A Signal Generator for 0 dBm output level at 10 kHz. The AC Voltmeter should indicate -14 dBm ± 1 dB.

7.3.2 Evaluation of Narrowband Sensitivity

a. Interconnect the equipment as shown in Figure 7-2.

b. Energize the equipment.

c. Set the Model NM-17/27 Bandwidth switch to the 1 kHz position, the Function switch to the FI position, and the Attenuator switch to the -40 dB position.

d. Tune the Model NM-17/27 to 32 MHz and adjust the Calibrate control for a convenient dB level on the Output Meter.

e. Set the Model 606A Signal Generator output level for 50 μV (no modulation) and tune to 32 MHz and for maximum indication on the Model NM-17/27 Output Meter.

f. Reduce the Signal Generator output level for a Model NM-17/27 Output Meter scale indication 20 dB higher than the noise level set in step d. The Signal Generator output level minus 20 dB should be equal to or less than shown in Figure 2-3 for a 1 kHz bandwidth at 32 MHz.

g. Repeat steps d., e., and f. for frequencies of 1.0, 0.1 and 0.01 MHz. Additional frequencies may be tested as desired. Use Signal Generator Model 651B below 50 kHz.

h. Add 6 dB to the levels measured in step f. to obtain the radiation sensitivity in dBμV/m using the Model 92197-3 41" Rod Antenna. These values should be equal to or less than the values shown in Figure 2-1 for a 1 kHz bandwidth.

7.3.3 Evaluation of Broadband Sensitivity

a. Interconnect the equipment as shown in Figure 7-2 using the Model 91263-1 Impulse Generator in place of the Model 606A Signal Generator.

b. Energize the equipment.

c. Set the Model NM-17/27 Bandwidth switch to the 50 kHz position, the Function switch to Peak, hold time 0.05 secs., the Attenuator switch to the -20 dB position, and tune to 32 MHz.

d. Set the Model 91263-1 output level to 0 dBμV/MHz.

e. Adjust the Model NM-17/27 Calibrate control for a convenient dB level on the Output Meter.

f. Increase the Model 91263-1 Impulse Generator output level for an increase in the Model NM-17/27 Output Meter scale indication of exactly 10 dB. The impulse generator output level minus 10 dB should be equal to or less than shown in Figure 2-4 for a 50 kHz bandwidth at 32 MHz.

g. Repeat steps c. thru f. for frequencies of 10, 1.0 and 0.5 MHz.

h. Repeat steps c. thru f. for frequencies of 0.1 and 0.05 MHz using a bandwidth of 10 kHz.

i. Repeat steps c. thru f. for frequencies of 0.02 and 0.01 MHz using a bandwidth of 1 kHz.

j. Add 6 dB to the levels measured in step f. to obtain the radiation sensitivity in dBμV/m/MHz for the bandwidths used. These values should be equal to or less than the values shown in Figure 2-2.

7.3.4 Evaluation of Narrowband Signal Overload

a. Interconnect the equipment as shown in Figure 7-2.

b. Energize the equipment.

c. Set the Model NM-17/27 Bandwidth switch to the 10 kHz position, the Function switch to Peak, hold time to 0.05 secs., the Attenuator switch to the +60 dB position, and frequency to 10 MHz.

d. Adjust the Model 606A generator RF output level (unmodulated) to +13 dBm (1 volt) and tune to 10 MHz and for maximum response on the NM-17/27 Output Meter.

e. Adjust the Model NM-17/27 CAL control for an Output Meter indication of 40 dB (convenient indication level).

f. Increase the Model 606A generator RF output level in 1 dB increments; equal 1 dB increases on the Model NM-17/27 Output Meter scale indicates linear operation of the Model 94607-1 Coupler

amplifier. Note the signal generator output level at which the Model NM-17/27 Output Meter indication departs from linearity by 1 dB. This is the point of overload and should be +21 dBm (2.5V) or greater, see Table 2-3.

g. Add 6 dB to the point of overload level measured in step f. to obtain the overload level for radiated signals. This level should be 5 volts/meter or greater, see Table 2-2.

7.3.5 Evaluation of Broadband Signal Overload

a. Interconnect the equipment as shown in Figure 7-2 except replace the Model 606A generator with the Model 91263-1 impulse generator.

b. Energize the equipment.

c. Set the Model NM-17/27 Bandwidth switch to the 50 kHz position, the Function switch to Peak, hold time to 0.05 secs., the Attenuator switch to the 0 dB position and frequency to 10 MHz.

d. Set the Model 91263-1 impulse generator output level to +70 dBμV/MHz. Adjust the Model NM-17/27 CAL control for an Output Meter indication of 30 dB.

e. Reverse polarity of the impulse generator signal. The Model NM-17/27 indication should remain at 30 dB ± 1 dB.

f. Increase the Model 91263-1 impulse generator in 1 dBμV/MHz increments. Equal 1 dB increases on the NM-17/27 Output Meter, with no significant change in the indication when pulse polarity is changed, indicates linear operation of the Model 94607-1 Coupler amplifier. Note the impulse generator output level at which the Model NM-17/27 Output Meter indication departs from linearity by 1 dB. This is the point of overload and should be +80 dBμV/MHz or greater, see Table 2-3.

g. Add 6 dB to the point of overload level measured in step f. to obtain the overload level for radiated signals. This level should be +86 dBμV/m/MHz or greater, see Table 2-2.

7.4 ALIGNMENT AND ADJUSTMENT PROCEDURES

7.4.1 Disassembly Procedure

a. Remove the four 4-40 x 1/2" flat-head screws from the back plate.

b. Remove the back plate.

7.4.2 Alignment Procedure

a. Interconnect the equipment as shown in Figure 7-1.

b. Energize the equipment.

c. Decrease the signal generator RF output level to under 1 μV.

d. Connect the DC voltmeter between the emitter of Q2 and the emitter of Q3 (across R7 and R8, component symbols are screened on the component side of the printed circuit board). The emitter of Q2 will be the most positive.

e. Adjust R5 to obtain 0.25 volts indicated by the DC voltmeter, then remove the voltmeter.

f. Adjust the signal generator to provide 0 dBm output at 500 kHz.

g. Adjust C3 for an RF voltmeter indication of -14 dBm. This sets the Antenna Preamp gain to -14 dB and the antenna correction factor (ACF) to +20 dB, allowing 6 dB for the 1/2 effective height of the Model 92197-3 rod antenna.

h. Adjust the signal generator to provide 0 dBm at 32 MHz.

i. Adjust C4 for an RF voltmeter indication of -14 dBm. This flattens the frequency response of the Antenna Preamp and sets the ACF to +20 dB at 32 MHz.

j. Since some interaction may occur, repeat steps f. thru i. as necessary.

k. Check the Preamp gain and ACF at 1, 10 and 20 MHz. These values should be -14 dB ± 1 dB and +20 dB ± 1 dB respectively.

l. Replace the signal generator and RF voltmeter with the Model 651B signal generator and Model 400D AC voltmeter.

m. Check the Preamp gain and ACF at 100 kHz and 10 kHz. These values should be -14 dB ± 1 dB and +20 dB ± 1 dB respectively.

n. As an alternate procedure, a sweep generator test may be substituted for steps f. thru m. IF this is done, C4 should be adjusted for maximum flatness up to 32 MHz. Then adjust C3 to obtain 14 dB loss through the Model 94607-1 Antenna Preamp in the flat region.

o. The alignment is completed. Paragraphs 7.3.2 thru 7.3.5 of the Acceptance Test Procedure can be performed to determine if the Antenna Preamp performance complies with specifications, Tables 2-2 and 2-3.

p. Replace the Preamp housing back plate.

7.5 FAULT ISOLATION PROCEDURE

If the Preamp does not perform in a normal manner, refer to the schematic diagram, Figure 9-1, and verify the circuit voltages shown, in absence of signal, using the DC Voltmeter. If the voltages are normal, check the input circuit for continuity. Check continuity of the RF output circuit and the RF output cable. Check the performance of the Model NM-17/27 EMI/FI Meter.

Section VIII

REPLACEABLE PARTS

8.1 INTRODUCTION

This section contains information for ordering replacement parts. Tables 8-1 thru 8-3 list the parts according to their functional groupings. Parts are listed in alpha-numerical order of their reference designators and indicate the Singer part number, the description, typical manufacturer of the part in a five-digit code, and the manufacturer's part number. Table 8-4 lists the typical manufacturers in numerical code number order.

Table 8-1. Parts List for Main Assemblies and Chassis

Ref. Desig.	Singer Part No.	Description	Mfr. Code No.	Mfr. Part No.
A1	1-004909-001	Assembly, Antenna Preamp	88869	
C1	1-900003-008	Capacitor, fixed, mica, 10 pF, ±5%, 500 Vdc	72136	DM15C100J
J1	S-11662	Connector, jack, TNC, bulkhead	11636	KA-71-02
J2	1-910132-001	Connector, jack, BNC, bulkhead	11636	UG-1094A/U
J3	1-910206-001	Connector, box mounting, 6 socket	71468	KPSE02E10-6S
J4	S-12412	Connector, jack, banana	83330	109
J5	S-12412	Connector, jack, banana	83330	109

Table 8-2. Parts List for Supplied Accessories

Qty.	Singer Part No.	Description	Mfr. Code No.	Mfr. Part No.
1	1-004915-001	Cable, power, 20 ft.. 4 in.	88869	
1	1-500783-284	Instruction Manual	88869	
1	1-910209-001	Banana Plug to Binding Post Adapter	88869	
1	1-910210-001	Banana Plug to BNC Adapter	88869	

Table 8-3. Parts List for Antenna Preamp Assembly, A1

Ref. Desig.	Singer Part No.	Description	Mfr. Code No.	Mfr. Part No.
C1		No Used		
C2	1-900003-030	Capacitor, fixed, mica, 100 pF, ±5%, 500 Vdc	72136	DM15F101J
C3	1-900013-004	Capacitor, variable, mica, 8 pF to 60 pF, 175 Vdc	72136	404
C4	1-900013-004	Capacitor, variable, mica, 8 pF to 60 pF, 175 Vdc	72136	404
C5	1-900104-001	Capacitor, fixed, ceramic, 0.1 μF, ±20%, 50 Vdc	00656	3420-050C-104M
C6	1-900104-001	Capacitor, fixed, ceramic, 0.1 μF, ±20%, 50 Vdc	00656	3420-050C-104M
C7	1-900057-107	Capacitor, fixed, electrolytic, 1.0 μF, ± 10%, 20 Vdc	56289	150D105X9020A2
C8	1-900057-119	Capacitor, fixed, electrolytic, 10 μF, ± 10%, 20 Vde	56289	150D106X9020B2
C9	1-900057-119	Capacitor, fixed, electrolytic, 10 μF, ± 10%, 20 Vdc	56289	150D106X9020B2
E1	1-906013-001	Bead, ferrite	02114	5659065/4B
E2	1-906013-001	Bead, ferrite	02114	5659065/4B
E3	1-906013-001	Bead, ferrite	02114	5659065/4B
L1	1-906003-007	Inductor, fixed, 0.33 μH, ±10%, 1150 mA	43543	DD-0.33
Q1	1-958084-001	Transistor, N-channel, J-FET	04713	MPF820
Q2	1-958055-001	Transistor, silicon, NPN	49675	2N5109
Q3	1-958088-001	Transistor, silicon, PNP	04713	2N5583
R1	1-945000-267	Resistor, fixed, composition, 100 megohm, ± 5%, 1/4 W	01121	CB1075

Table 8-3. Parts List for Antenna Preamp Assembly, A1 (Cont.)

Ref. Desig.	Singer Part No.	Description	Mfr Code No.	Mfr. Part No.
R2	1-945000-162	Resistor, fixed, composition, 1 kilohm, ± 5%, 1/4 W	01121	CB1025
R3	1-945000-186	Resistor, fixed, composition, 10 kilohm, ± 5%, 1/4 W	01121	CB1035
R4	1-945000-162	Resistor, fixed, composition, 1 kilohm, ± 5%, 1/4 W	01121	CB1025
R5	1-945037-007	Resistor, variable, cermet, 1 kilohm, ± 10%, 1/2 W	80740	62PR1K
R6	1-945000-186	Resistor, fixed, composition, 10 kilohm, ± 5%, 1/4 W	01121	CB1035
R7	1-945000-122	Resistor, fixed, composition, 22 ohm, ± 5%, 1/4 W	01121	CB2205
R8	1-945000-122	Resistor, fixed, composition, 22 ohm, ± 5%, 1/4 W	01121	CB2205
R9	1-945000-122	Resistor, fixed, composition, 22 ohm, ± 5%, 1/4 W	01121	CB2205

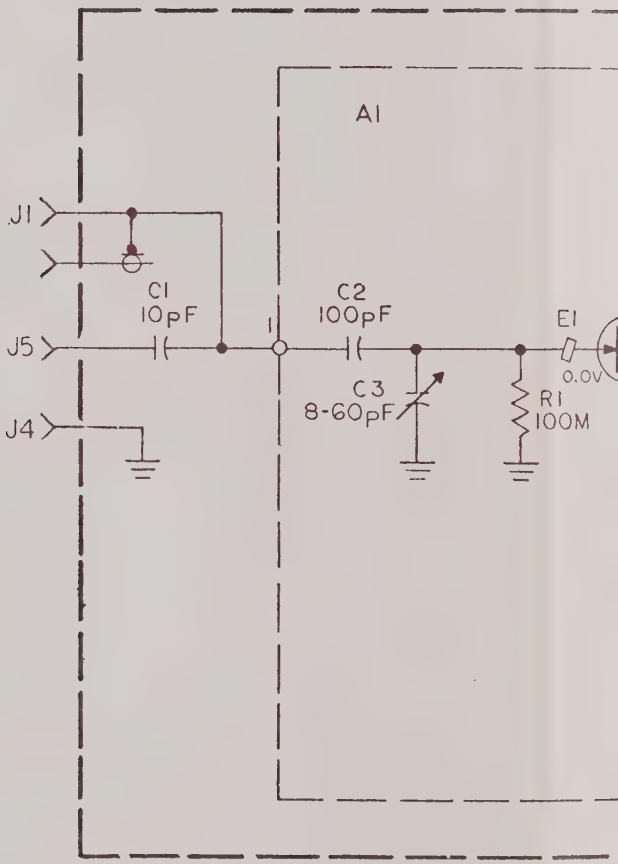
Table 8-4. Code List of Manufacturers

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbook H4-2.

Code No.	Manufacturer	Address
00656	Aerovox Corp.	New Bedford, Mass.
01121	Allen-Bradley Co.	Milwaukee, Wis.
02114	Ferroxcube Corp.	Saugerties, N.Y.
04713	Motorola, Inc.	Phoenix, Ariz.
11636	Kings Electronics Co.	Pasadena, Calif.
43543	Nytronics, Inc.	Alpha, N.J.
49675	RCA Electronic Prod. Div.	Camden, N.J.
56289	Sprague Electric Co.	North Adams, Mass.
71468	ITT Cannon	Santa Ana, Calif.
72136	Electro Motive Mfg. Co.	Willimantic, Conn.
80740	Beckman Instruments Inc.	Fullerton, Calif.
83330	Smith, Herman H. Inc.	Brooklyn, N.Y.
88869	Singer Instrumentation	Los Angeles, Calif.

Section IX

SCHEMATIC DIAGRAMS



NOTES: UNLESS OTHERWISE SPECIFIED

1. CAPACITORS ARE IN MICROFARADS.
2. RESISTORS ARE IN OHMS.

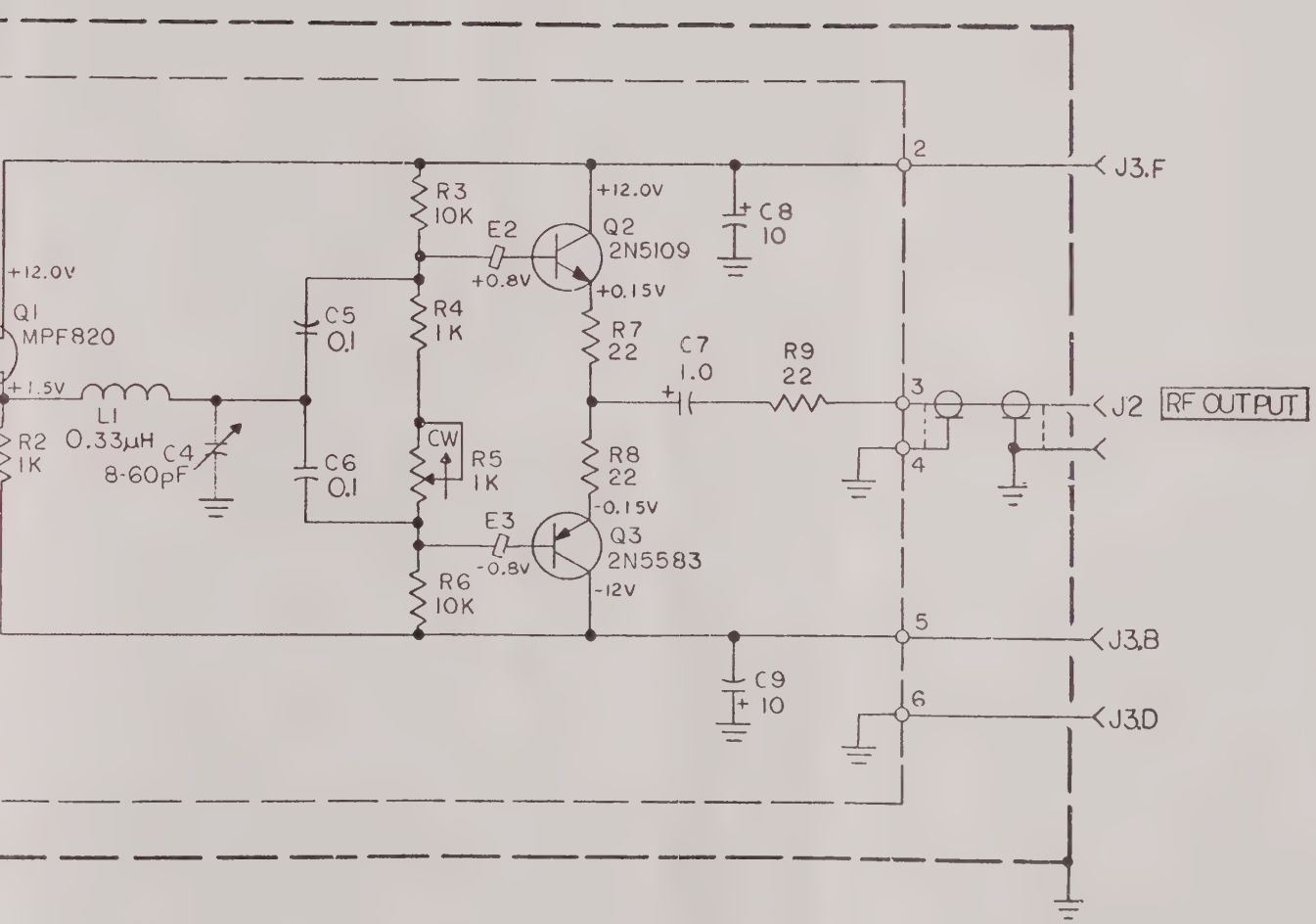


Figure 9-1. Scematic Diagram,

Model 94607-1 Rod Antenna

Preamp

Drawing No. 3-501389-001

Appendix A

ROD ANTENNA THEORY

A1 INTRODUCTION

This appendix is concerned with devices which couple energy from electromagnetic fields into RI-FI meters. The electromagnetic fields are caused by electrical currents; the nature of the field (magnitude and direction of E and H components) is a function of distance from these currents.

There is a great difference in the physical nature of the electromagnetic field at distances close to the source (i.e. distances $\ll \lambda/2\pi$, where λ is the wavelength of the incident field) and at distances far from the source (i.e. distances $\gg \lambda/2\pi$). In the former case at close distances the field is an "induction field" and components of electric field E and magnetic field H vary inversely as the square or cube of the distance from the source depending on the distance and the nature of the source. At far distances the field is a "radiation" field. There, both E and H vary as the inverse power of distance, and the disturbance behaves as a plane wave in the sense that E/H is equal to a constant equal to 120π (377) ohms, the "impedance of free space."

The function of the antenna is to extract a portion of the energy of the field and to deliver it to the RI-FI instrument. This may be done by sampling the E component (for example, with a rod or dipole antenna) or the H component (with a loop antenna).

A2 ANTENNA PARAMETERS: EFFECTIVE HEIGHT AND IMPEDANCE

The most significant characteristic of a receiving antenna of an RI-FI meter is its

"effective height" (sometimes called "effective length," "electrical height," or "conversion length.") The effective height (h_e) is the ratio of the voltage (E_a) induced in the antenna as measured at the (open circuit) antenna terminals to the component of the incident electric field intensity (E) parallel to the plane of polarization of the antenna, or

$$h_e = \frac{E_a}{E} \qquad (A.1)$$

where h_e is expressed in meters,

E_a is expressed in microvolts (or volts),

E is expressed in microvolts/meter (or volts/meter).

Thus, if the incident electric field intensity (E) at the antenna is 1000μv/m, and the voltage (E_a) measured at the antenna terminals is 100 μv, then the effective height of the antenna is:

$$h_e = \frac{E_a}{E} = \frac{100\ \mu v}{1000\ \mu v/m} = 0.1\ m$$

A3 THE ROD ANTENNA

The rod antenna is a long thin metal cylinder or solid rod, usually silver plated brass or steel. The rod is generally from 1 to 3 meters in length, and about one-quarter inch in diameter. It is usually built in two or more sections which connect or telescope together to save space in packing, and it has an adapter-connector at the base for attachment to the RI-FI meter, coupler or preamplifier.

The effective height of a rod in free space, completely isolated from ground and other objects, and oriented broadside to the incident electric field, is equal to its actual length (ℓ). That is,

$$h_e = \ell \text{ (meters) for the isolated rod.} \qquad \text{(A.2)}$$

With the rod oriented perpendicularly (i.e. vertically) to a perfect ground of infinite conductivity,

$$h_e = \frac{\ell}{2} \qquad \text{(A.3)}$$

where ℓ is the physical length of the antenna. With the antenna oriented vertically, h_e expresses the relationship between the voltage induced in the antenna and the vertical component of the incident field E. The effective height expression of (A.3) applies exactly for most practical situations, within the limits of experimental measurement. Exceptions will occur where ground conductivity has been lowered appreciably by extremely long periods of excessive dryness.

The factor 2 which appears in equation (A.3), because of the effect of the proximity of a perfect ground, may be explained by the theory of images. The vertical rod and ground behave electrically as though a mirror image of the actual rod were located below the surface of the ground, and the ground removed. The antenna as a transmitter develops a field strength (E) having a peak value double that of the isolated rod, for the same voltage input to the antenna. By reciprocity, the incident field on the antenna as a receiver induces a voltage E_a equal to one-half that for the isolated rod. From the definition (A.1) for effective height, the value for the rod in the presence of ground is therefore as given in (A.3). Thus, for example, a rod 1 meter in length has an effective height in the presence of ground of 0.5 meters.

Formula (A.3) for effective height is valid so long as

[1]

$$\ell < \frac{\lambda}{8} \qquad \text{(A.4)}$$

where λ is the wavelength:

$$\lambda \text{ (meters)} = \frac{c}{f} = \frac{3 \times 10^8 \text{ (m/sec)}}{f \text{ (Hertz)}} \qquad \text{(A.5)}$$

Thus for a rod which is 1 meter in actual length, the smallest wavelength satisfying (A.4) is 8 meters, corresponding to a frequency of 37.5 MHz.

The rod has an internal impedance given by

$$Z_a = R_a + \frac{1}{j\omega C_a} \qquad \text{(A.6)}$$

where R_a is the radiation resistance and C_a is the electrostatic capacitance of the rod and ground plane. Typical values of capacitance are 10 pf for a 1-meter and 24 pF for a 2-meter rod. Thus, for example, at the maximum frequency for a 1-meter rod (37.5 MHz) the capacitive reactance is 425 ohms, and it increases with decreasing frequency. If condition (A.4) holds, then R_a is given by:

[2]

$$R_a = 40\pi^2\left(\frac{\ell}{\lambda}\right)^2 \qquad \text{(A.7)}$$

where R_a is radiation resistance in ohms.

At $\lambda = 8\ell$, the limiting case, R_a is only 6.5 ohms, and the resistance decreases with decreasing frequency.

A.4 ROD ANTENNA COUPLING CONSIDERATIONS

It is most desirable to obtain a maximum power matching condition at the antenna terminals. According to the maximum power transfer theorem, this is obtained when the impedance presented by the instrument to the antenna is the complex conjugate of the antenna impedance. When this condition obtains, the output power is equal to $E_a^2/4R_a$.

From equations (A.2) and (A.7) and the definition of effective height it is then given by a quantity which does not depend upon the length of the antenna:

$$P_a = \frac{1}{160}\left(\frac{E\lambda}{\pi}\right)^2 \qquad (A.8)$$

Unfortunately, in the frequency range in which this antenna is normally used, this equation has very little meaning, since the radiation resistance R_a is so small that it is difficult to construct circuits which will effectively match it.

REFERENCES

[1] John D. Kraus, "Antennas", McGraw-Hill Bood Co., Inc., 1950

[2] F. E. Terman, "Radio Engineering," McGraw-Hill, 3rd ed., 1947